UNITED STATES PATENT AND TRADEMARK OFFICE
CERTIFICATE OF CORRECTION

PATENT NO.   : 6,928,565 B2
APPLICATION NO. : 09/834846
DATED   : August 9, 2005
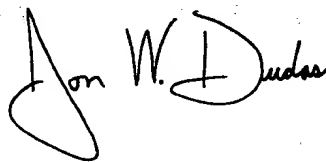INVENTOR(S)   : Watts, Jr. et al.

It is certified that error appears in the above-identified patent and that said Letters Patent is hereby corrected as shown below:

The title page showing the illustrative figure should be deleted to be replaced with the attached title page.

The drawing sheets, 1-5 consisting of Figs. 1-9, should be deleted to be replaced with drawing sheets, consisting of Figs. 1-9, as shown on the attached page.

Signed and Sealed this

Thirteenth Day of March, 2007

JON W. DUDAS
Director of the United States Patent and Trademark Office

(12) **United States Patent**

Watts, Jr. et al.

(10) **Patent No.:** **US 6,928,565 B2**

(45) **Date of Patent:** **Aug. 9, 2005**

(54) **COMPUTER SYSTEM THERMAL LAP MANAGEMENT METHOD AND APPARATUS**

(75) Inventors: La Vaughn F. Watts, Jr., Austin, TX (US); Kofi Nkisah Dadzie, Austin, TX (US); Yi Zhang, Austin, TX (US)

(73) Assignee: Dell Products L.P., Round Rock, TX (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 736 days.

(21) Appl. No.: 09/834,846

(22) Filed: Apr. 13, 2001

(65) **Prior Publication Data**

US 2002/0152406 A1 Oct. 17, 2002

(51) Int. Cl.[7] G06F 1/20; G06F 1/28

(52) U.S. Cl. 713/322; 713/300; 361/687; 361/695; 374/102

(58) Field of Search 713/300, 322, 713/323, 324, 340; 361/93.8, 103, 124, 161, 676, 687, 695; 374/100, 101, 102, 178; 702/63, 99, 130, 132, 136

(56) **References Cited**

U.S. PATENT DOCUMENTS

5,652,893 A *	7/1997	Ben-Meir et al.	.... 713/310
5,713,030 A *	1/1998	Evoy	.... 713/322
5,936,836 A	8/1999	Scholder	
5,969,939 A	10/1999	Moss et al.	
6,005,770 A	12/1999	Schmitt	
6,058,009 A	5/2000	Hood, III et al.	
6,311,287 B1 *	10/2001	Dischler et al.	.... 713/601
6,397,343 B1 *	5/2002	Williams et al.	.... 713/501
6,487,668 B2 *	11/2002	Thomas et al.	.... 713/322
6,535,798 B1 *	3/2003	Bhatia et al.	.... 700/293
6,574,740 B1 *	6/2003	Odaohhara et al.	.... 713/323

OTHER PUBLICATIONS

Y. Tada, A. Takimoto, and Y. Hayashi, *Heat Transfer Enhancement In A Convective Field By Applying Ionic Wind.* The Gordon and Breach Publishing Group, Sep. 1996.
Brian S. Akre, *Ford To Test System that Eats Smog.* Global Platinum & Gold, Inc. Market Discussions, Nov. 1998.
Sam Atwood, *AQMD Investigates Ozone-Eating Catalyst.* AQMD Advisor newsletter, Jan. 1997.
Jeffrey B. Hoke, Ronald M. Heck and Terry C. Poles, *PremAir Catalyst System-A New Approach to Cleaning the Air,* SAE Technical Paper Series—Presented at International Fall Fuels & Lubricants Meeting Oct. 1999.

* cited by examiner

Primary Examiner—Thuan Du

(74) *Attorney, Agent, or Firm*—Haynes and Boone, LLP

(57) **ABSTRACT**

A computer comprises a central processing unit, at least one fan disposed for providing cooling to the at least one central processing unit, and a thermal manager. The thermal manager monitors a temperature of the central processing unit and dynamically controls a throttling of the central processing unit and the at least one fan according to a thermal management algorithm.
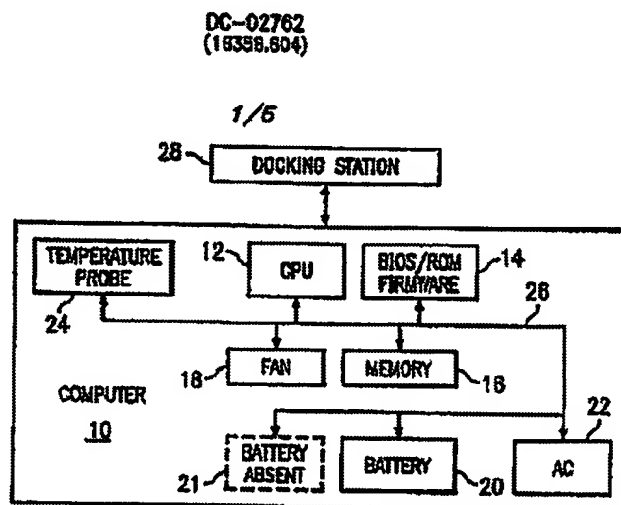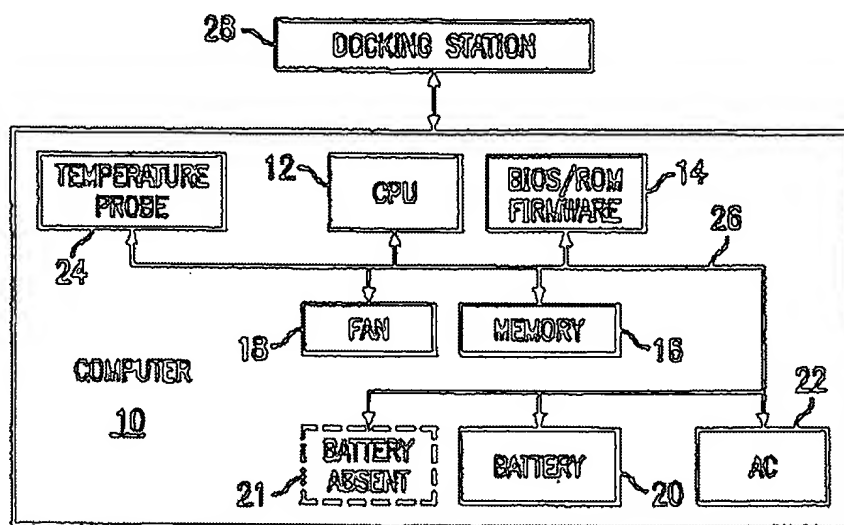
33 Claims, 9 Drawing Sheets

DC-02762
(16398.604)

1/6

Fig. 1

Fig. 1

Fig. 2

COOL LAP 7	SMART CPU	HDD TIMER	MONITOR TIMER	SYSTEM TIMER	ACPI	AMBIENT	SURFACE TEMP
OFF	OFF	OFF	OFF	OFF	ON	22.8	23

TIME (MINUTES)	0	5	10	15	20	25	30
CPU TEMP	37	56	60	57	59	60	59
CPU TEMP IN F	98.6	132.8	140	134.6	138.2	140	138.2
CASE TEMP	24.8	28.2	31.8	34.6	36.3	38.1	38.9
CASE TEMP IN F	76.64	82.76	89.24	94.28	97.34	100.58	102.02
CPU SPEED	752	752	752	752	752	752	752
APPLICATION	EXCITE EXTREME 3D FASHION SHOW						

TIME (MINUTES)	35	40	45	50	55	60
CPU TEMP	53	59	51	60	59	58
CPU TEMP IN F	127.4	138.2	123.8	140	138.2	136.4
CASE TEMP	40.2	41.2	41.6	42.1	42.6	42.8
CASE TEMP IN F	104.36	106.16	106.88	107.78	108.68	109.04
CPU SPEED	752	752	752	752	752	752
APPLICATION	EXCITE EXTREME 3D FASHION SHOW					

Fig. 3

Fig. 4
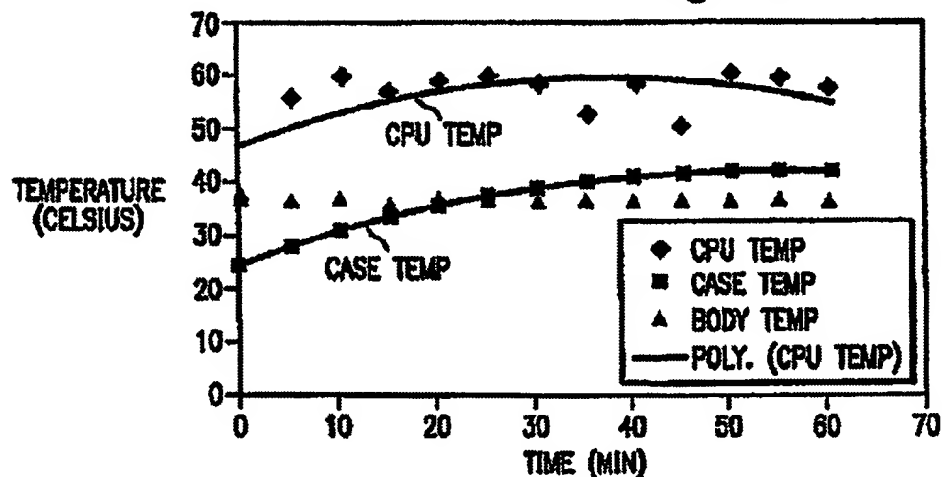
COOL LAP 7b	SMART CPU	HDD TIMER	MONITOR TIMER	SYSTEM TIMER	ACPI	AMBIENT	SURFACE TEMP
ON	ON	OFF	OFF	OFF	ON	23.1	24.4

TIME (MINUTES)	0	5	10	15	20	25	30
CPU TEMP	32	48	47	48	49	49	50
CPU TEMP IN F	89.6	118.4	116.6	118.4	120.2	120.2	122
CASE TEMP	26.5	30	32.2	33.7	34.5	35.2	35.8
CASE TEMP IN F	79.7	86	89.96	92.66	94.1	95.36	96.44
CPU SPEED	693	694	604	604	605	602	604
APPLICATION	EXCITE EXTREME 3D FASHION SHOW						

TIME (MINUTES)	35	40	45	50	55	60
CPU TEMP	49	49	50	50	50	50
CPU TEMP IN F	120.2	120.2	122	122	122	122
CASE TEMP	36.2	36.5	36.8	37	37.3	37.5
CASE TEMP IN F	97.16	97.7	98.24	98.6	99.14	99.5
CPU SPEED	604	603	608	604	604	604
APPLICATION	EXCITE EXTREME 3D FASHION SHOW					

U.S. Patent Aug. 9, 2005 Sheet 3 of 5 **6,928,565 B2**

Fig. 5

Fig. 6

30

Fig. 7

DATA FLOW IN COOL LAP
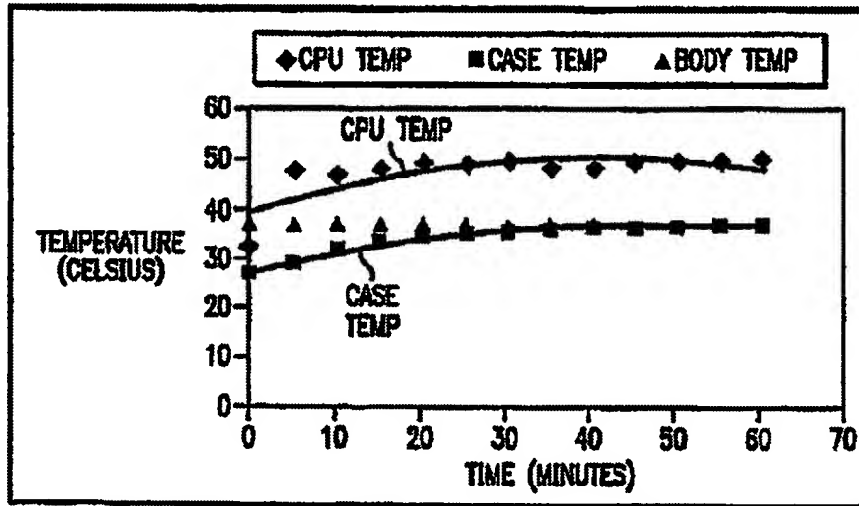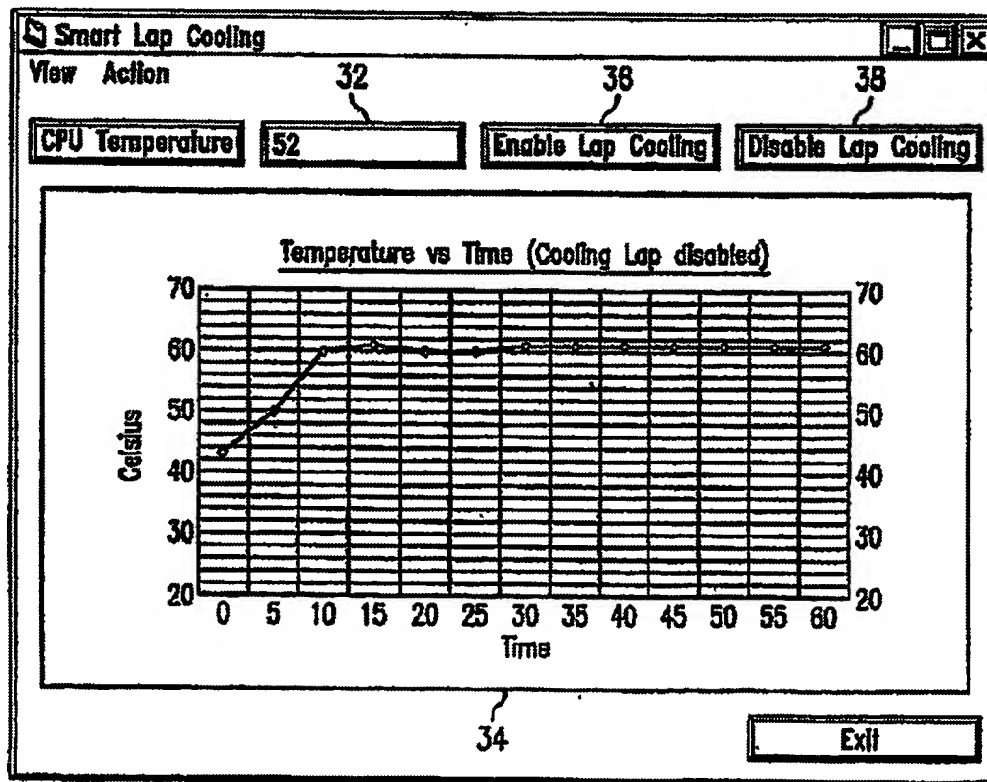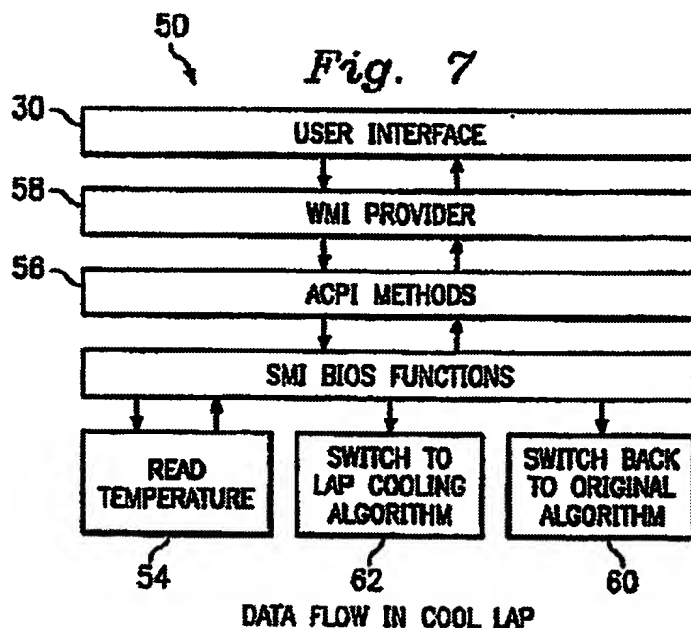
Fig. 8

LOWER RANGE	VALUE	HIGHER RANGE	VALUE	ACTION
TEMP_ABS_LOW:	−128	RANGE_1_HI:	23	No Action
RANGE_1_LO:	20	RANGE_2_HI:	25	No Action
RANGE_2_LO:	22	RANGE_3_HI:	26	TH1, Fan1 Low
RANGE_3_LO:	23	RANGE_4_HI:	27	TH1, Fan1 Hi
RANGE_4_LO:	24	RANGE_5_HI:	55	TH1, Fan1 Hi, Fan2 Low
RANGE_5_LO:	47	RANGE_6_HI:	65	TH2, Fan1 Hi, Fan2 Hi
RANGE_6_LO:	58	RANGE_7_HI:	90	TH3, Fan1 Hi, Fan2 Hi
RANGE_7_LO:	55	TEMP_CRITICAL−1:	101	TH4, Fan1 Hi, Fan2 Hi
RANGE_8_LO:	90	TEMP_CRITICAL:	102	TH4, Fan1 Hi, Fan2 Hi, ACPINOTIFY
				SwOff (Power off the unit)

U.S. Patent   Aug. 9, 2005   Sheet 5 of 5   **6,928,565 B2**

Fig. 9

LOWER RANGE	VALUE	HIGHER RANGE	VALUE	ACTION
TEMP_ABS_LOW:	−128	RANGE_1_HI:	23	No Action
RANGE_1_LO:	20	RANGE_2_HI:	25	No Action
RANGE_2_LO:	22	RANGE_3_HI:	26	TH1, Fan1 Low
RANGE_3_LO:	23	RANGE_4_HI:	27	TH1, Fan1 Hi
RANGE_4_LO:	24	RANGE_5_HI:	50	TH1, Fan1 Hi, Fan2 Low
RANGE_5_LO:	42	RANGE_6_HI:	60	TH2, Fan1 Hi, Fan2 Hi
RANGE_6_LO:	53	RANGE_7_HI:	75	TH3, Fan1 Hi, Fan2 Hi
RANGE_7_LO:	60	TEMP_CRITICAL−1:	101	TH4, Fan1 Hi, Fan2 Hi
RANGE_8_LO:	90	TEMP_CRITICAL:	102	TH4, Fan1 Hi, Fan2 Hi, ACPINOTIFY
				SwOff (Power off the unit)